Mercury Rising

Investigating toxic chemicals in the ocean with the GEOTRACES program

By Chris Parsons

| Photo credit: Bill Schmoker - PolarTREC

Trace elements are rare – they are found in just 'trace' amounts in the environment - but they can be incredibly important. Some trace elements, like iron, are micro-nutrients, required only in minute quantities, but they're essential for life. However, some trace elements, like mercury, can be highly toxic. The GEOTRACES Program studies the occurrence of these rare, but very important, elements in the ocean, mapping their occurrence and investigating the processes controlling the global distribution of dozens of trace elements and isotopes (different forms of an element, with slightly different atomic weights). One of the most important toxic trace elements that they study is the pollutant mercury.

Mercury can cause neurological damage, suppression of the immune system and developmental abnormalities. Mercury in the marine environment was identified as a health risk for humans when it infamously caused an outbreak of "Minamata disease". This disease is so-called because in the 1950s, in Minamata, Japan, local people started to display neurological problems and children were being born with developmental abnormalities, which were ultimately traced back to consuming mercury-contaminated seafood.

Mercury occurs naturally in the rocks of the Earth crust and can be released into the environment via volcanic activity or weathering of rocks. Mercury can also enter the environment from human activities such as the burning of fossil fuels, especially coal-fired power stations, or through the incineration of waste. Mercury is also still widely used in small-scale gold mining.

In the marine environment mercury is often found as a compound – methylmercury. This form of mercury "bioaccumulates" in marine species to levels that put ecosystem and human health at risk. Most plants and animals can regulate their metal content to a certain point – but some metals build up in an organism over its lifetime, in a process known as "bioaccumulation". In addition, animals feeding upon these species take in the methylmercury contained within their prey which, in turn, bioaccumulates within themselves. As you go up through the marine food chain, mercury "biomagnifies" and the levels of mercury in the tissues of marine species gets higher and higher. This ultimately results in top predators having the highest concentrations of mercury in their tissues, sometimes at levels that can have toxic effects upon marine species.

The GEOTRACES program helps document mercury levels in seawater, discovering inputs of mercury into the marine environment, and the ways in which it is transformed from one kind of mercury to another. Their research has discovered, for example, that melting permafrost in the Arctic is releasing mercury into river systems and the ocean waters. Also, melting ice has caused a 40 percent increase in methylmercury in sea ice. GEOTRACES-based measurements have also found that humans have increased the amount of mercury in the surface ocean to about three and half times what it was before the Industrial Revolution. As this mercury will be taken up by marine species, this implies that mercury levels in fish and other oceanic organisms will have increased substantially as well.

Data from the GEOTRACES programme is available on an open access policy, including an online Atlas showing mapping these data. This Atlas provides a benchmark against which future changes in marine systems can be assessed. It's also a valuable online teaching resource and helps provide scientific information in a way that is easy for decision-makers and the general public to digest.

(From left to right) Dr. Carl Lamborg (University California, Santa Cruz, USA), Dr. Lars-Eric Heimburger-Boavida (MIO, France) and Dr. Katlin Bowman (University California, Santa Cruz, USA) at the North Pole. (Photo credit: Katlin Bowman.)

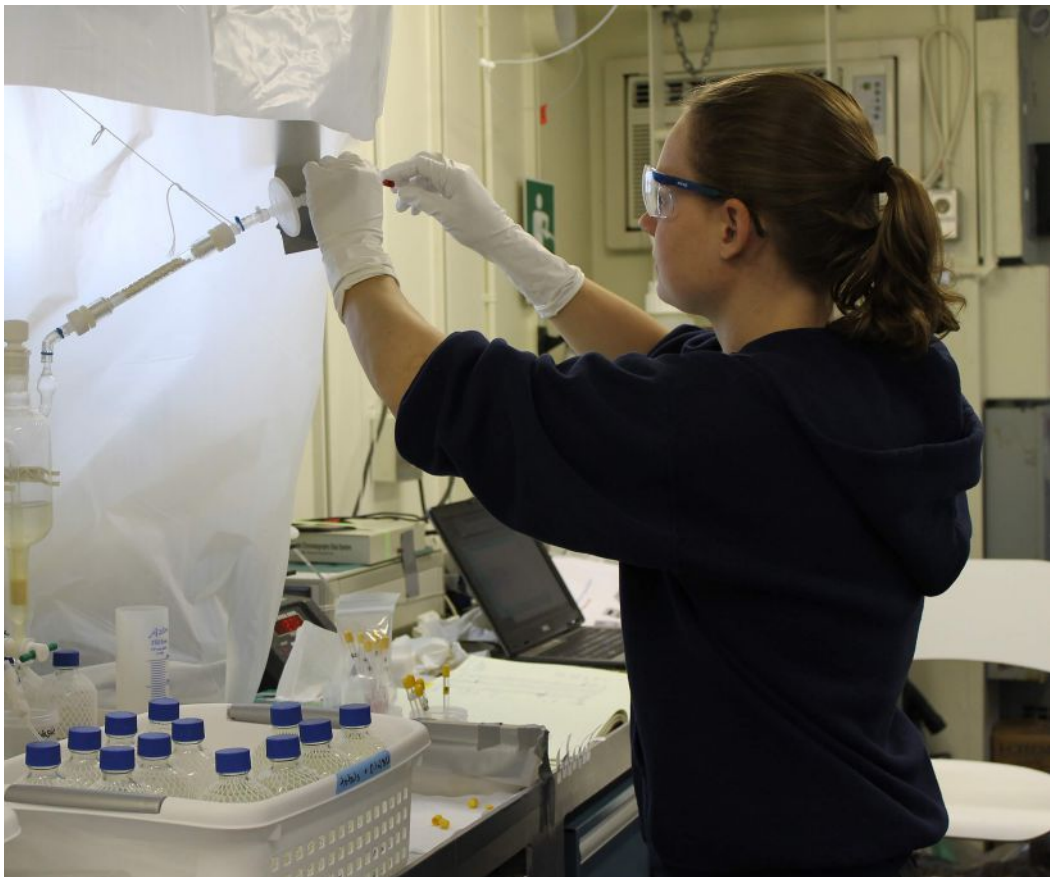
A Truly International Collaboration

An important factor in the development of the GEOTRACES program was the realization that the problem to be address was too large for any one nation to handle. The program, which is supported by the US National Science Foundation's chemical oceanography program along with other institutions (from other countries such as France, Germany, Netherlands, UK, India and Japan), involved a multi-country partnership of scientists and vessels. To date, 126 research voyages have been completed, with 19 countries involved in leading these expeditions, and scientists from 36 countries participating.

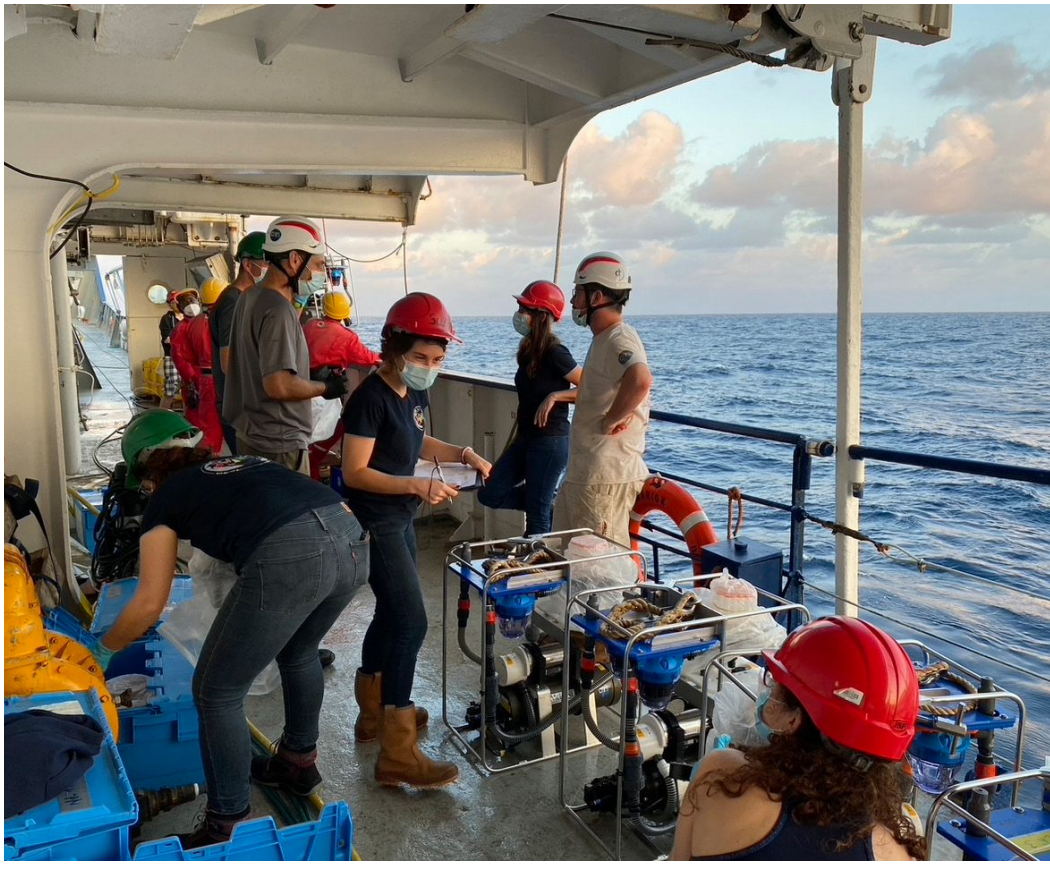
The GEOTRACES Program is also training the next generation of marine scientists, with international summer schools and training and scientific workshops held in locations such as India, South Africa and China (both in Beijing and Taipei) and by employing a diverse team of early career scientists on its expeditions.

"Conducting science among a diverse group is inspirational and motivating," said Dr. Laura Whitmore, an early career researcher with the University of Alaska Fairbanks. "GEOTRACES promotes collaboration and discussion through workshops, but the time spent at sea with other scientists can't be beat as a way to learn about and be inspired by research."

"Experiencing different cultures and learning from scientists from different countries was a big plus to me," added Dr. Wen-Hsuan Liao, who is originally from Taiwan and is currently with the Laboratoire des Sciences de l'Environnement Marin, Institut Universitaire Européen de la Mer in Plouzané, France. "I made a lot of friends through this international program, both senior scientists and the ones in my generation. I believe this special environment makes me more curious about what I am doing. You will also have a wider view, not only care about the oceanic regions near your country but also the other regions, then the global ocean."



Dr. Gretchen Swarr, WHOI. (Photo credit: Katlin Bowman)



(Photo credit: Laurent Godard)

Life Onboard a GEOTRACES Research Cruise

Scientists refer to the ocean-going research expeditions as "cruises", but they are far from the floating vacations the term evokes. A research cruise is a very intense active periods, with researchers getting little sleep, as they need to work at all times, day and night (as soon as the ship arrives to the sampling station). Work sometimes occurs under difficult weather conditions as well, so it can be quite challenging. But there is a lot of excitement when discoveries are made.

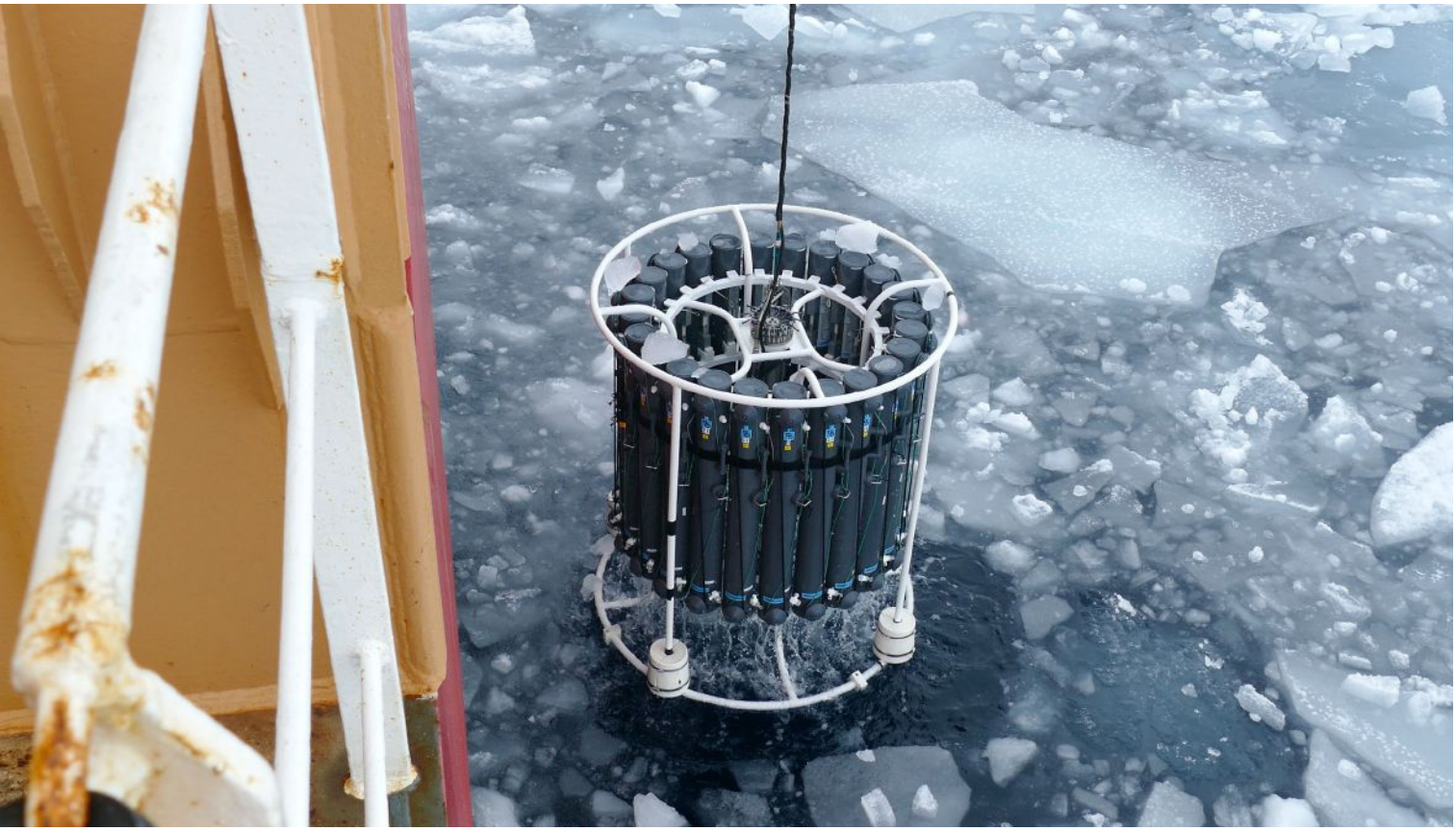
"Working on a research vessel is a fickle balance between being pushed to your limits and having the time of your life." said Dr. Katlin Bowman from University of California. "There was a day in the North Atlantic Ocean where the ship was stationed on the outskirts of a hurricane. The tiny window of our lab filled completely with sky then nothing but ocean, oscillating back and forth like a seesaw. I was fighting sea sickness all day, pipetting tiny drops of acid into bottles of seawater and occasionally catching lab supplies before they flew off the bench. Despite these challenges, that day was thrilling. The seawater in those bottles came from over two miles below the surface and hadn't seen the light of day in decades. The work is always worth the hardships, we were able to answer some big questions with the data collected that day."

However, at the end of a busy day working in the lab or on deck, there were chances to relax. Dr. Liao wound down at the end of the day by soaking in a bathtub—a rare luxury unique to their Japanese research vessel. Dr. Bowman adds, "for fun, we enjoy the spoils of pre-internet times, playing card games in the library and music on the aft deck." Dr. Laramie Jensen from the University of Washington, recounted, "we all really enjoyed watching the sunsets (or sunrises) on the back deck or the stars on the bow at night." They also danced and sang on the deck, had trivia competitions, and even had a talent show on one trip. However, quiet time was also important. "I really enjoyed reading or listening to music on my own in my bunk or elsewhere on the ship. Finding a moment or two completely alone can be tough in a small space so I learned to relish that as much as spending time with others," said Dr. Jensen. On one expedition, the captain even led a group yoga class in the TV room or on deck (on calm sunny days).

The GEOTRACES Program is providing essential data on ocean chemistry as well as measuring levels of toxic trace elements such as mercury. The data the program gathers also provides insight into the changing climate and oceanic processes. The United Nations Decade of Ocean Science for Sustainable Development has recognized the importance of the program on an international level by endorsing the program as an official Decade activity. This recognizes not only the important scientific data the program collects, but also its function as a role model for successful and effective international collaboration in ocean science.

For further information about GEOTRACES: https://www.geotraces.org

NSF Video on GEOTRACES: https://www.youtube.com/watch?v=NwvMnma0Cxw&t=2s



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